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# BULLETIN

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## *Sewage Disposal for Residences in Unsewered Districts*

**Published at Helena, by the State Board of Health.**

The promotion of improved methods of disposal of human excreta at unsewered homes is one of the most important duties of municipal, county, state and national health officials.

Resolution 13th Annual Conference State Health Officials.

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# SEWAGE DISPOSAL FOR RESIDENCES IN UNSEWERED DISTRICTS

BY

W. M. COBLEIGH, Director H. B. FOOTE, Bacteriologist

Division of Water and Sewage.

## INTRODUCTION.

There are two reasons why practical and sanitary sewage disposal devices should be installed for residences in unsewered districts. In the first place human excreta (stools and urine) are filthy and so obnoxious that it is very natural to shun them. Consequently people quite instinctively are eager to adopt practical methods of disposing of excreta.

In the second place accumulations of excreta are potentially very dangerous. Human refuse often contains germs of disease. These germs may come not only from persons who are sick with some disease but also from those who, apparently well, are "carriers" of infection. It follows that a great deal of intelligence should be exercised in disposing of excreta by cleanly and sanitary methods in order that people may avoid contact with human filth and also prevent it from gaining access to the inside of the body.

It is for this reason that people should be instructed how to construct not only "practical" but "sanitary" sewage disposal devices. Insanitary and uncleanly methods of disposal may permit excreta to spread to water supplies and to foods; thence to the mouths of persons. Contact with excreta may also be the means of transmitting infection to the inside of the body. Much preventable disease in this country results from insanitary disposal of human excreta.

## *Diseases Caused by Germs in Excreta.

"Among the most important diseases caused by living poisons, or germs, contained in and spread by human excreta are typhoid fever, dysentery, Asiatic cholera, tuberculosis, hookworm disease, and roundworm, eelworm, and tapeworm diseases.

**Typhoid fever.** This disease is caused by germs which come from human filth. Typhoid germs, like seeds, as those of wheat and corn, do not originate spontaneously but they come by natural descent from others of their kind. Their continued existence in nature depends upon their getting into and multiplying in the bodies of human beings. They come from persons and only from persons. From the bodies of infected persons they are discharged in the stools and urine. They enter the bodies of other persons by being swallowed. Unless we get something which is contaminated with human filth into our mouths and swallow it we can not have typhoid fever. Persons sick with typhoid fever discharge in their stools and urine tremendous numbers of these germs. Some persons who are apparently in good health carry in and discharge from their bodies typhoid germs just as do persons ill with the disease. These persons are called "typhoid carriers". Typhoid germs are very small; 12,000 of them placed end-to-end, or 36,000 of them placed side-by-side, measure only about an inch. Like molds and yeasts they are plants; and under favorable conditions (as in milk, for instance) they multiply rapidly, so that in a few hours a single germ may give rise to thousands of its kind. Hundreds of them may be contained in a small particle of feces or in a small drop of urine. They are colorless and cause no disagreeable

*Lumsdan, Stiles and Freeman. Public Health Bulletin No. 68, U. S. Public Health Service.

odor or taste in water or milk. Therefore, water which is clear or milk which is sweet, if contaminated with very small quantities of human filth—such as may be conveyed on a fairly clean looking finger or by a fly—may be teeming with the living germs of typhoid fever.

**Dysentery and Asiatic Cholera.** These diseases result from the swallowing of germs which have their source only in human excrement and are spread for the same reasons and in the same ways as are the germs of typhoid fever.

**Tuberculosis.** While most of the infective discharges from the lungs of consumptives are given off by the mouth, it should be kept in mind that some of this matter is swallowed and also that some persons have tuberculosis of the bowels or of the kidneys. Therefore, human excreta often contain the germs of tuberculosis.

**Hookworm disease.** This disease is caused by worms that live in the small bowel. The parasites, when full grown, are about half an inch in length. They attach themselves to the wall of the bowel, which they wound. The worms lay eggs in large numbers which are passed in the stools and which escape from the body in no other way. Under favorable conditions of climate and soil on ground polluted by human excrement containing these eggs, tiny worms hatch out within a few hours from the eggs. These young worms grow and when about 1 to 2 weeks old, but still only about one-fortieth of an inch long, and therefore scarcely visible to the naked eye, they may be swallowed, or they may burrow through the skin—especially of barefooted children—and in so doing cause that condition known as "ground itch," "dew itch," "dew sores," "toe itch," etc. From the skin these minute worms get into the blood and gradually make their way to the bowels, where they grow to adult worms, which in their turn lay eggs.

There are in the United States at least 2,000,000 people who suffer from hookworm disease. This serious disease results solely from contact with soil polluted with human excrement containing hookworm eggs.

**Round worms and pin worms.** These worms live in the bowels of persons. They lay numerous eggs that are discharged from persons only in the excrement. The eggs and young worms are scattered around with the excrement, and upon being swallowed by persons they develop in the bowels into grown worms which in turn lay eggs. The presence of any of these common worms in a person means that that person has swallowed the discharges from human intestines.

**Tapeworm disease.** Tapeworms live in the bowel. They lay eggs by thousands. These eggs escape from persons in the stools. If such stools are scattered around, the eggs may be swallowed by live stock. The eggs from the beef tapeworm, if swallowed by cattle produce "beef measles". The eggs of the pork tapeworm, if swallowed by swine, produce "pork measles". Thus pollution of the soil with human excrement may lessen the value and wholesomeness of meat. If meat containing live tapeworm cysts ("measles") is eaten by persons, the young worms grow into adult tapeworms. Some kinds of tapeworm eggs passed in the stools can, if swallowed by man, be the direct cause of disease. Thus, tapeworm disease in persons results either directly or indirectly from uncleanly distribution of human excreta about the premises.

From the foregoing discussion of some of the serious diseases affecting the human race, it is clear that human excreta, if not prevented from reaching human bodies, constitute the most dangerous of all matter with which we are liable to come into contact in the course of our daily lives.

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*Stiles. American Journal of Public Health, Vol. X, No. 1, January, 1920.

## The Way Human Filth is Spread.

It is easy to understand that human filth is dangerously spread under the conditions generally found at unsewered homes. Upon leaving the body, human excreta may be spread around by various means, of which the following are the most important.

By water, through surface washing or subsoil seepage.

By the hands or feet of persons or by animals.

By flies and other insects.

Water. Rain or other water can carry filth into drinking water, either by washing over the ground or by seeping through the ground into a well, spring, stream, or lake. Tubes left by decayed tree-roots and the burrows of insects or of cray-fish or of worms may act as channels to carry the filth considerable distances underground. Water supplies can become contaminated by excreta conveyed on the hands or feet of persons, on the feet and bodies of poultry and of other animals, and by worm and insects. Water contaminated with human excreta if used for washing certain foods or for washing vessels used for storing or handling foods—milk vessels being particularly important in this connection—will spread filth to foods. Thus water can serve both directly and indirectly as an agent in the spread of human excreta—with the various disease germs which such matter may contain—from person to person.

Persons and animals. Persons and animals, such as poultry, dogs, cats, rats, etc., walking over soil polluted with human excreta get some of the filth on their feet, and then "track" this filth to the well top, the spring bank, the yard where children play, or into the kitchen, dining room, and other parts of the house. Hands soiled with filth either from accident or carelessness while a person is meeting the calls of nature, or from handling objects contaminated in any way with human excreta, carry excreta directly into human mouths or to food and drink which reach human mouths.

Flies and other house insects. Flies breed in and feed on human filth. These same flies frequent the kitchen and dining room, crawl over foods, fall into the milk, walk on the lips of sleeping children, and smear the filth from their feet and their bowels on everything they touch. Of all household insects the fly appears to be most important in spreading human filth.

Considering the many ways in which human filth may be spread, the frequency with which germs of disease are found in it, the minute size and large numbers of these germs, there is no mystery about the widespread and frequent occurrence of certain diseases in our unsewered (rural) districts."

## How to Prevent the Diseases Caused by Human Filth.

To prevent the diseases caused by germs in human waste, it is necessary to dispose of all such material by means of sanitary sewage disposal devices. The proper operation of such devices will prevent the scattering of excreta and the spreading of excreta to the mouths of persons by foods and water and by contact.

## Types of Sewage Disposal Devices and Their Rating.

In this bulletin the designs of four types or systems of sewage disposal devices will be illustrated and described. The names of these devices are:

1. The pit privy
2. The pail or can privy.
3. The chemical closet.
4. The septic tank with soil distribution of effluent.

In the introduction it was stated that people instinctively desire to avoid human filth by the installation of "practical" sewage disposal devices, and that on account of the dangerous nature of human filth

people should be taught how to construct "sanitary" disposal systems. *Stiles defines the adjectives "practical" and "santiary" used in this connection in the following terms.

"From the standpoint of the average person involved the word "practical" means that : (1) the original installation must cost little or nothing; (2) the privy must require no upkeep; (3) it must require no cleaning; (4) it must be without undue odor; and (5) must be "fool proof."

From the viewpoint of the health officer, a privy to be practical must be one: (1) which he can induce landlords to install; (2) which must be in keeping with the pocket-book of the poor; (3) which must not inhibit the subsequent adoption of a sewer system; (4) which must be within his budget to administer; (5) which must not make too many enemies in the population; (6) which must not raise too much political antagonism; (7) which must last as long as required; and (8) for which he can obtain labor if it requires scavenging.

From the standpoint of the cautious biologist, either bacteriologist or zoologist, a privy to be "sanitary" must be one which he is willing to recommend and for which he is willing to assume reasonable responsibility as to the spread of disease. More specifically: (1) it must protect the water supply; and (2) it must be structurally inaccessible to animals, including mammals, birds, reptiles, mollusks, and arthropods.

To harmonize all of these requirements in a single type of privy is theoretically and practically an impossibility. Accordingly, my first conclusion is that we must make up our minds to recommend certain types of privies and to admit or tolerate certain other types, according to local conditions, which are not within our control. It might, therefore, be wise to speak of "sanitary" privies to be recommended, "improved" privies to be permitted and "temporary" privies to be tolerated.

Further I must conclude that in selecting the types to be recommended, permitted, or tolerated, we must place the premises upon which our selections are based far back of the privy itself and we must study: (1) the mentality and characteristics of the community; (2) the permanent possibility of regular and efficient inspection; (3) the permanent availability of efficient labor for scavenging; (4) the density of the population; (5) the climate; and (6) the geological formation, with the fauna and flora.

The purpose of this preliminary study may be summarized in two statements: (1) It is unreasonable to expect a poor and ignorant negro laborer to install as good a privy as we can expect an educated white man to provide for his family; and (2) our fundamental purpose is to improve existing sanitation as rapidly as circumstances will permit, and this purpose can be realized only by an evolution, not by a revolution.

In this connection let us not inhibit results by overlooking the fact that this world is governed by three things, namely, principle, policy and price. Any health officer who overlooks this fact will spend more of his time defending himself against attacks than he spends in constructive public health work. We must be leaders, not drivers.

The Atlanta conference, considering construction alone, classified privies as follows:

| | | Per Cent |
|---|---|---|
| (1) | Water-tight construction, namely, prevention of soil-pollution | 25 |
| (2) | Construction, proof against vertebrates | 25 |
| (3) | Fly-proof construction | 25 |
| (4) | Lack of exposure of contents, as in cleaning or moving | 25 |

Under this plan the following maximum ratings are given to the sewage disposal devices that will be described in this bulletin.

| System. | Per Cent |
|---|---|
| The pit privy | 50 |
| The pail or can privy without chemicals | 75 |
| The chemical closet | 75 to 100 |
| The septic tank | 75 to 100 |
| The vault system with scavenging | 50 to 75 |
| The surface privy closed in back | 25 |
| The surface privy open in back | 10 |
| Absence of privy | 0 |

## THE PIT-PRIVY SYSTEM.

The method of disposing of human excreta in a pit in the ground covered with a properly constructed privy to insure privacy and convenience will be described under the title, the pit-privy system.

Under the plan of Stiles to select different types of privies to be "recommended," "permitted" or "tolerated" in accordance with standards of rating, the pit system can be selected as a method to be "permitted" altho in rural communities only.

That the pit privy is far from perfect is fully appreciated in making this selection. That the system has many disadvantages is perfectly evident. Even when constructed according to improved designs, the pit privy has a maximum rating of only 50%. To maintain this rating such a system must receive intelligent care in operation and in upkeep. Through neglect, the system will soon deteriorate to the surface privy class with a rating of 10% to 25%.

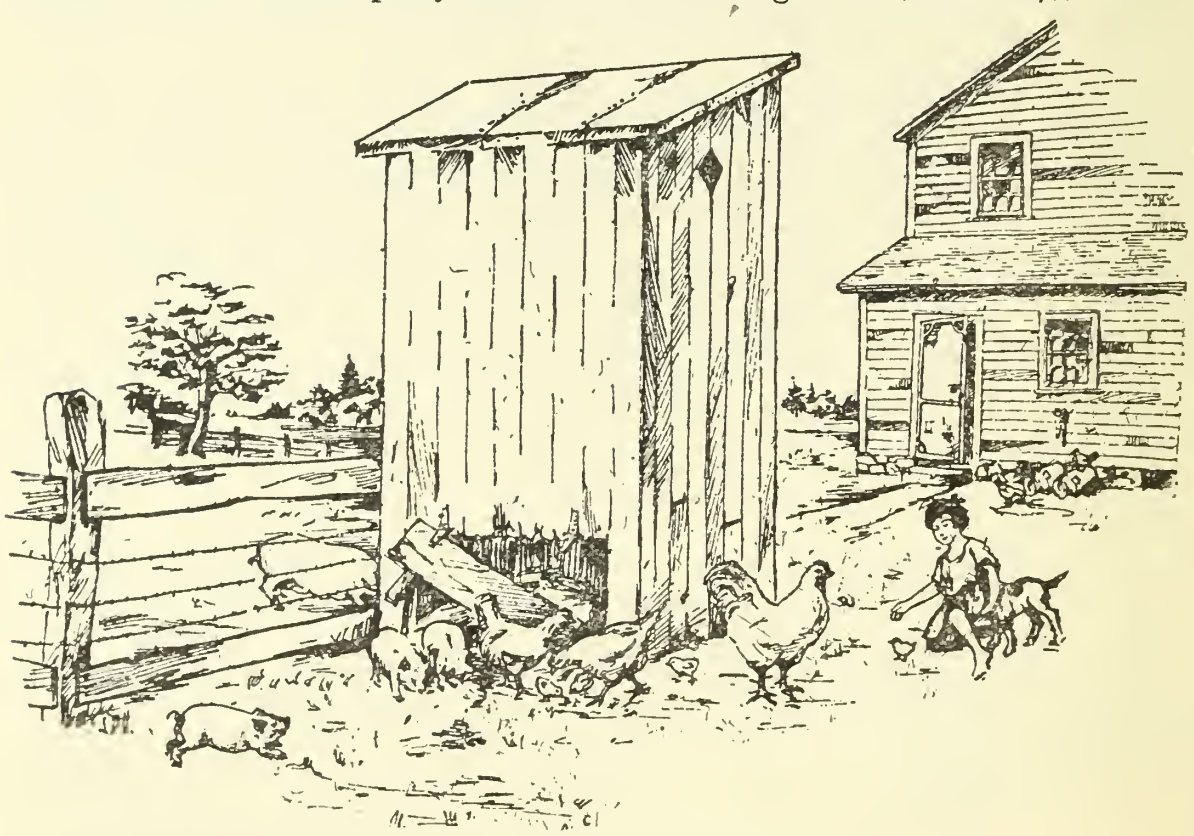

Fig. 1.

On account of its low rating the pit privy can not be placed in the class of sewage disposal devices to be recommended. It can not be rated as a "sanitary" type. As a type to be "permitted" in rural districts, the pit privy is a practical necessity. From the

viewpoint of the average person it is a "practical" system. Therefore under the sanitary standards now prevailing in rural districts the pit-privy system is the one most likely to be adopted.

On the other hand, this rating of the pit-privy should not be advocated without at the same time setting forth higher ideals for the ultimate solution of the sewage problem for country residences. The pit-privy is only one step in a process of evolution.

When the low rating of the pit system is more generally appreciated, there will follow no doubt a gradual improvement in sani-

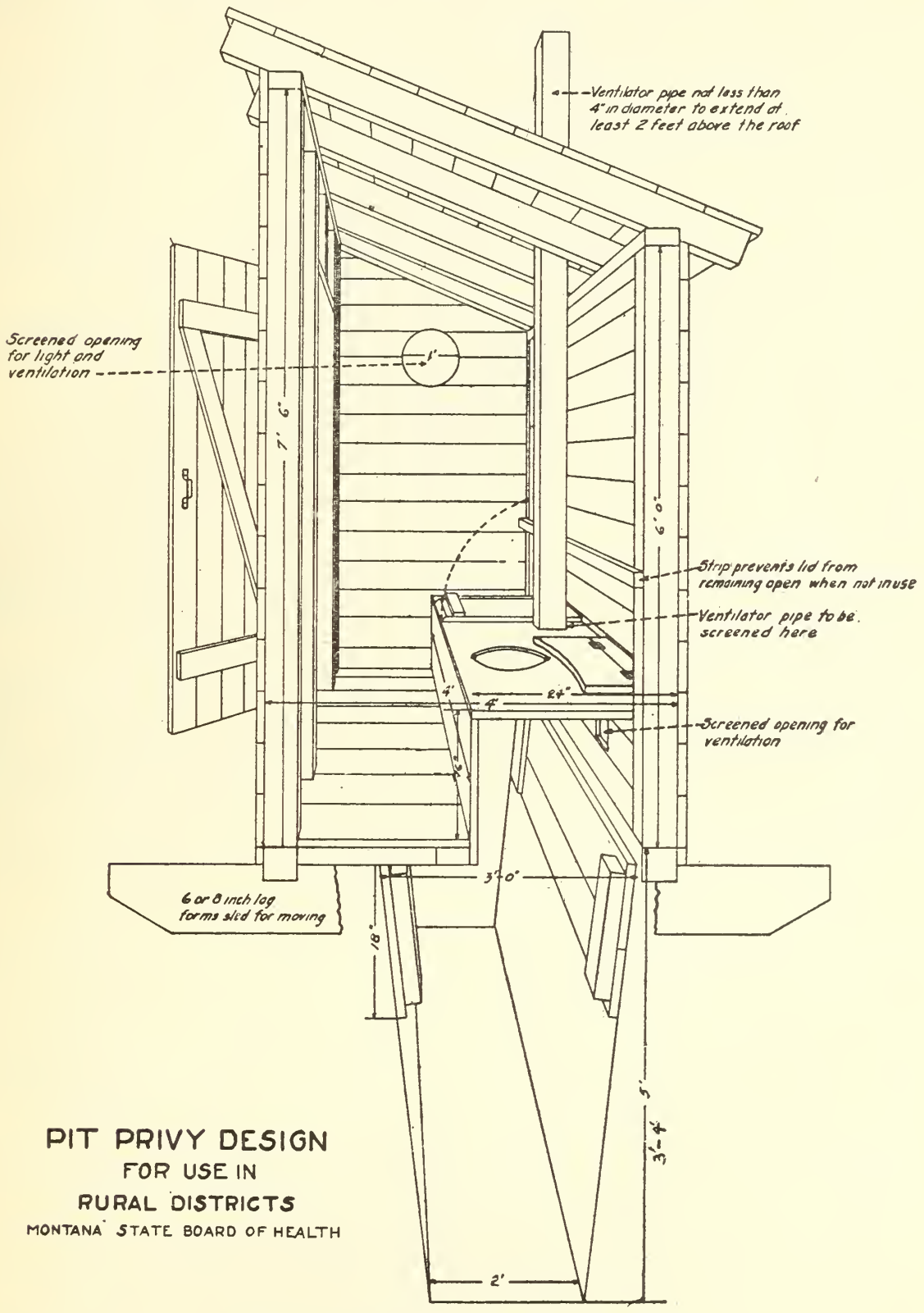


FIG. 2. DESIGN OF PIT PRIVY

tary standards in rural communities; and eventually sanitary systems that can be "recommended" will displace the pit system that is now rated as "permitted."

Therefore, the purpose of describing an improved design of pit-privy with suggestions regarding operation and upkeep, is to help raise the standard under which such a type is now constructed for farm habitations and isolated residence.

In small towns and villages the pit-privy should be classed as a type to be "tolerated" and considered in the light of a temporary device until a "sanitary" water carriage sewerage system can be constructed for the town; or until for each separate residence, a sanitary type of disposal plant can be provided.

Construction and Operation. To be given a maximum rating of 50%, a pit privy must be constructed according to an approved design, kept in good repair, operated in accordance with santiary principles, and located properly with respect to the residence and the local water supply.

The surface privy, open in back as shown in figue 1, (Minnesota State Board of Health) represents a type of privy construction that can not be "tolerated." At the best the maximum rating cannot be more than 10%.

From this type of privy excreta will be scattered about by animals, carried to food supplies on the feet and bodies of flies, and carried from place to place on the shoes of people who walk near the privy. This type of construction should, therefore, be condemned.

An improved design for a pit privy is shown in figures 2, 3, and 4. This design represents a movable type described by the Minnesota State Board of Health. The privy rests on a frame provided with logs to serve as runners. Resting on the ground the runners and frame foundation will be subject to influences which will cause the timbers to rot. Protection can be provided to a certain extent by creosoting the runners and the frame work. Further protection can be secured by the use of planks slightly embedded in the ground on which the runners can rest.

Figure 2 shows the privy in place over the pit. The seat is provided with hinged covers so designed that they will fall automatically into place after use and thus prevent the entrance of flies to the privy pit. Provisions are made for ventilation, and all openings are screened to keep out flies. Light is admitted through two screened openings or windows in opposite side walls.

The door design shows a durable construction made to fit closely to keep out flies. To keep the door closed at all times spring hinges or a weight and pulley attachment are provided.

The length and width of the pit should be adjusted to meet the requirements made necessary by the size of the privy. The depth of the pit should be between 3 and 4 feet. A deep pit should be avoided because the excreta should not be stored too near the ground water level. Seepage from the pit should pass through as much soil as possible before reaching the ground water supply. This precaution offers some protection to well water supplies in the vicinity of the privy. It will be advisable in some localities to line the pit with boards to prevent caving.

Finally an earth bank should be thrown up against the boards on the front and rear of the privy to prevent flies from getting into the pit.

Moving the Privy to a New Pit. When the pit is filled with excreta, one of two procedures is necessary. Either the excreta must be removed from the pit or the privy moved to a newly dug pit. The latter procedure is recommended. Cleaning the pit is not only a disagreeable task, but there is danger of spreading the excreta in the

operation of cleaning. It is therefore, easier and safer to move the privy to a new pit. Since the privy is built on runners, it can easily be moved as shown in figure 4.

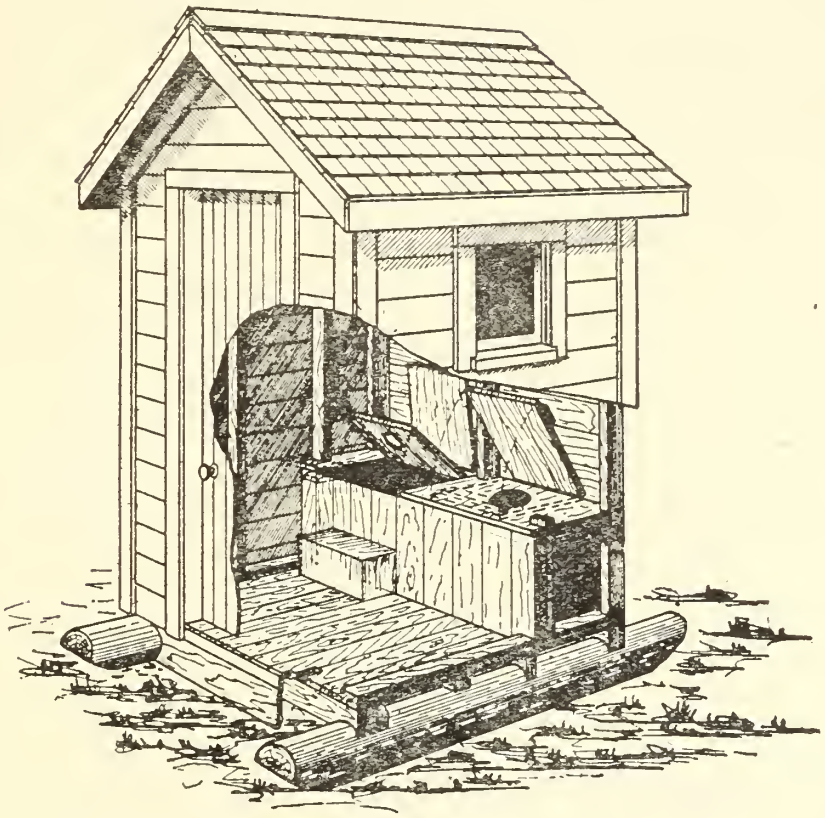

Fig. 3.

The old pit should be filled with earth to cover up the excreta. By this procedure it is possible to avoid the dangers involved in scavenging or handling the excreta.

Location. The protection of the local water supply is the chief reason for selecting a proper location for a pit privy. The distance between the privy and the well of an isolated residence will vary in accordance with soil conditions. Ordinarily one hundred feet is considered an acceptable distance. This, however, will depend upon various conditions. There is danger of direct contamination of well water supplies in limestone formations and in cases where the ground water level is near the surface.

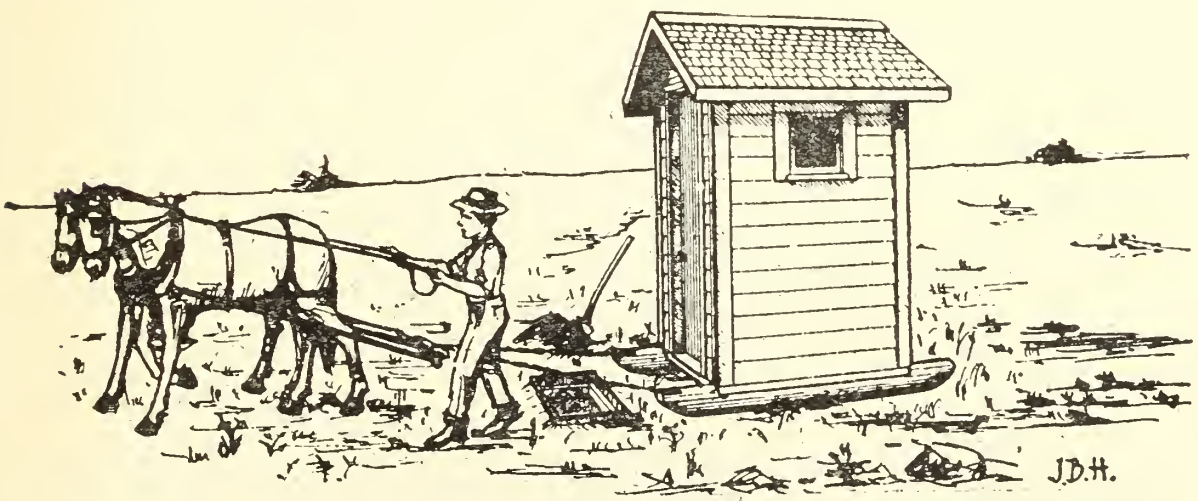


Fig. 4.

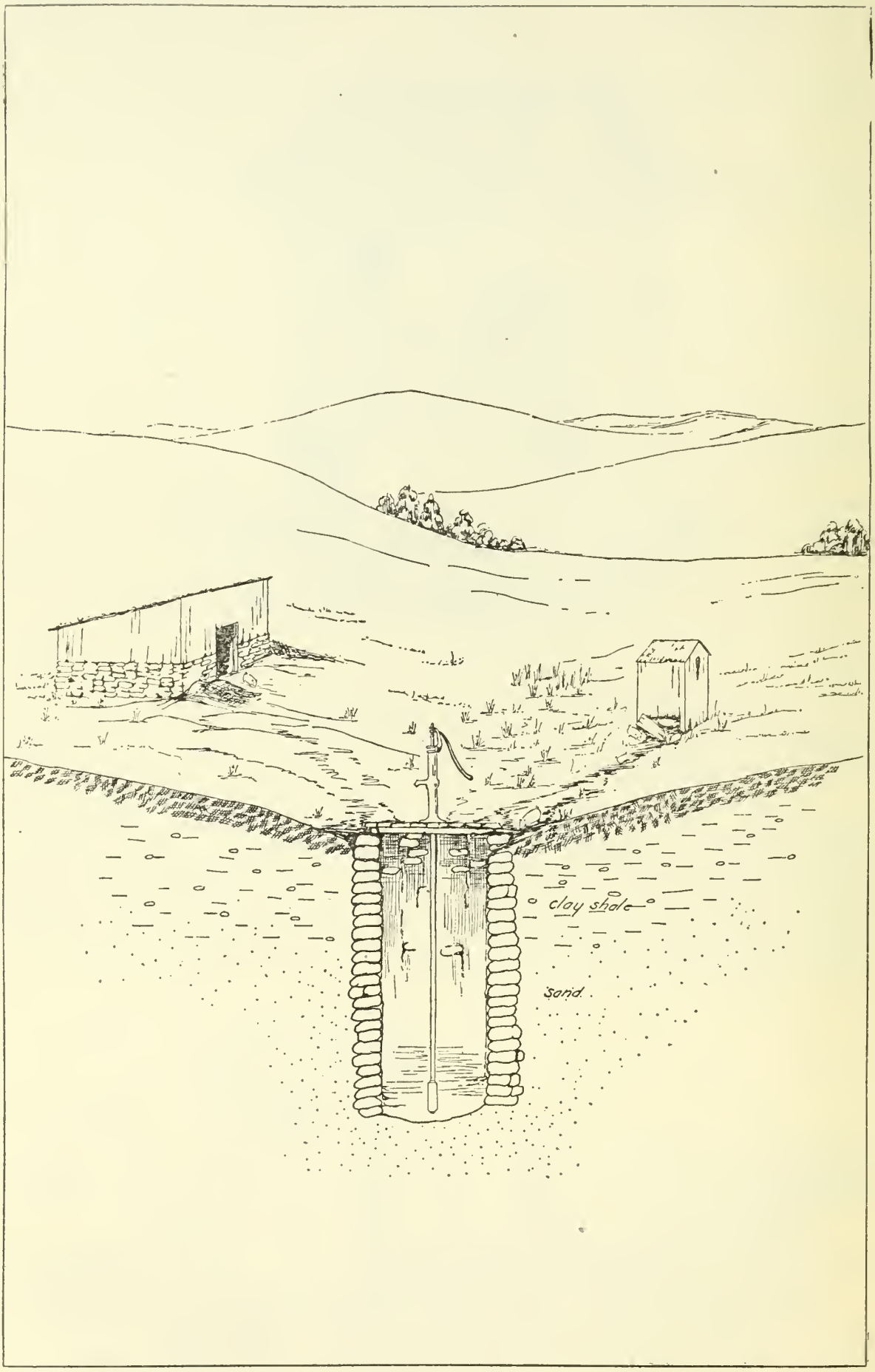


Fig. 5. Insanitary Privy Improperly Located and a Poorly Constructed Well

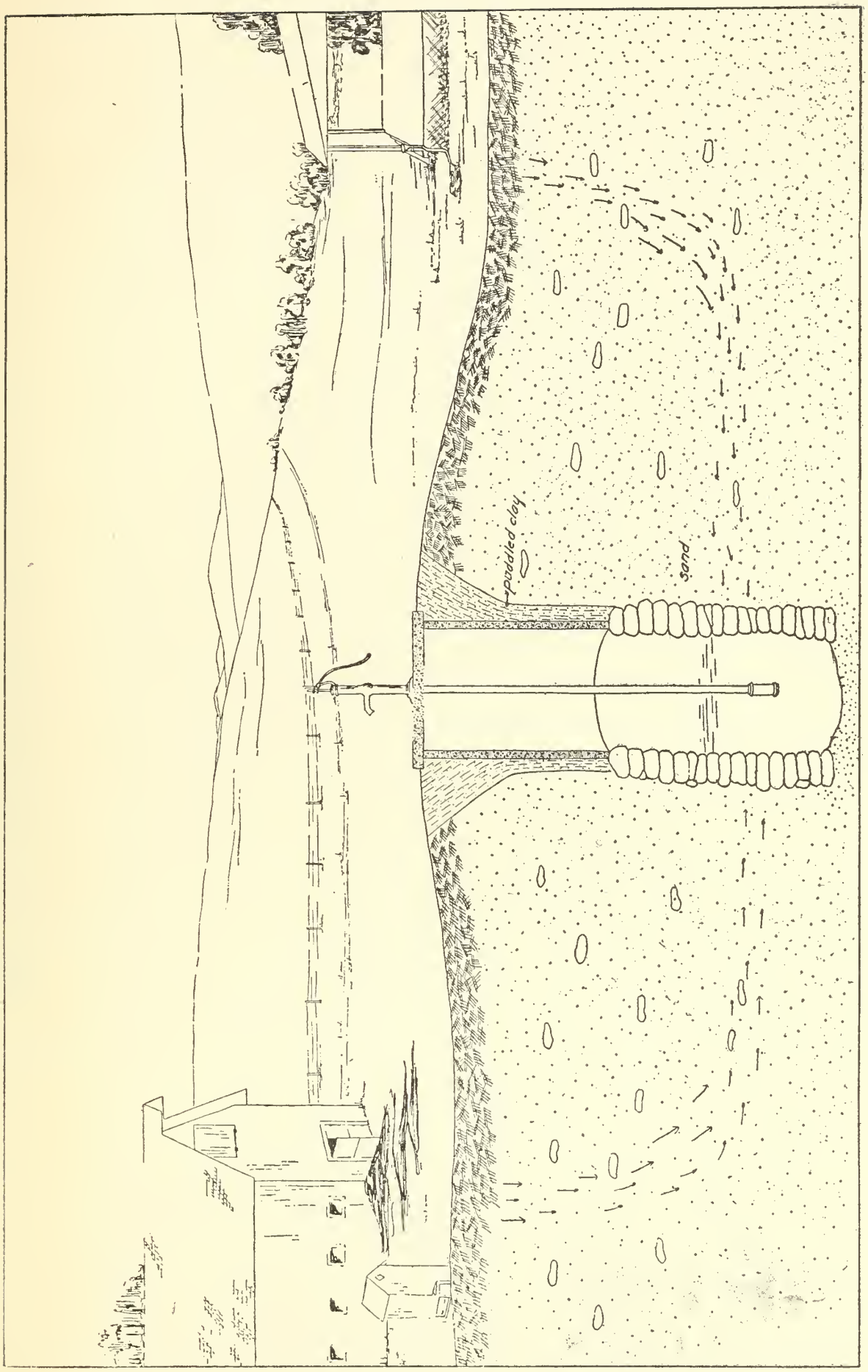


Fig. 6. A Pail Privy Properly Located and a Properly Constructed Well

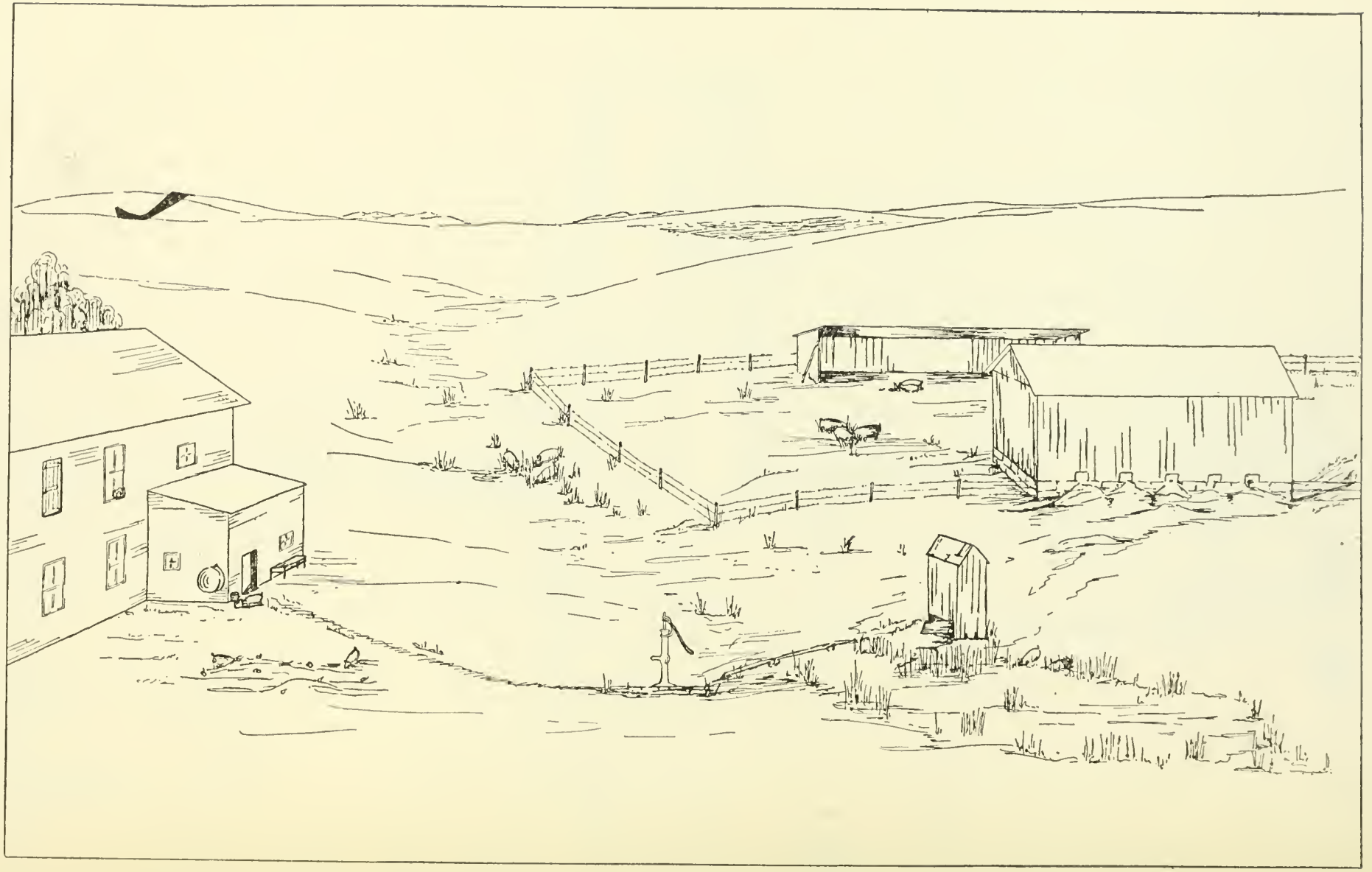

Fig. 7. Farm Habitation Showing an Insanitary Privy of the Surface Type and an Improperly Located and Constructed Well.

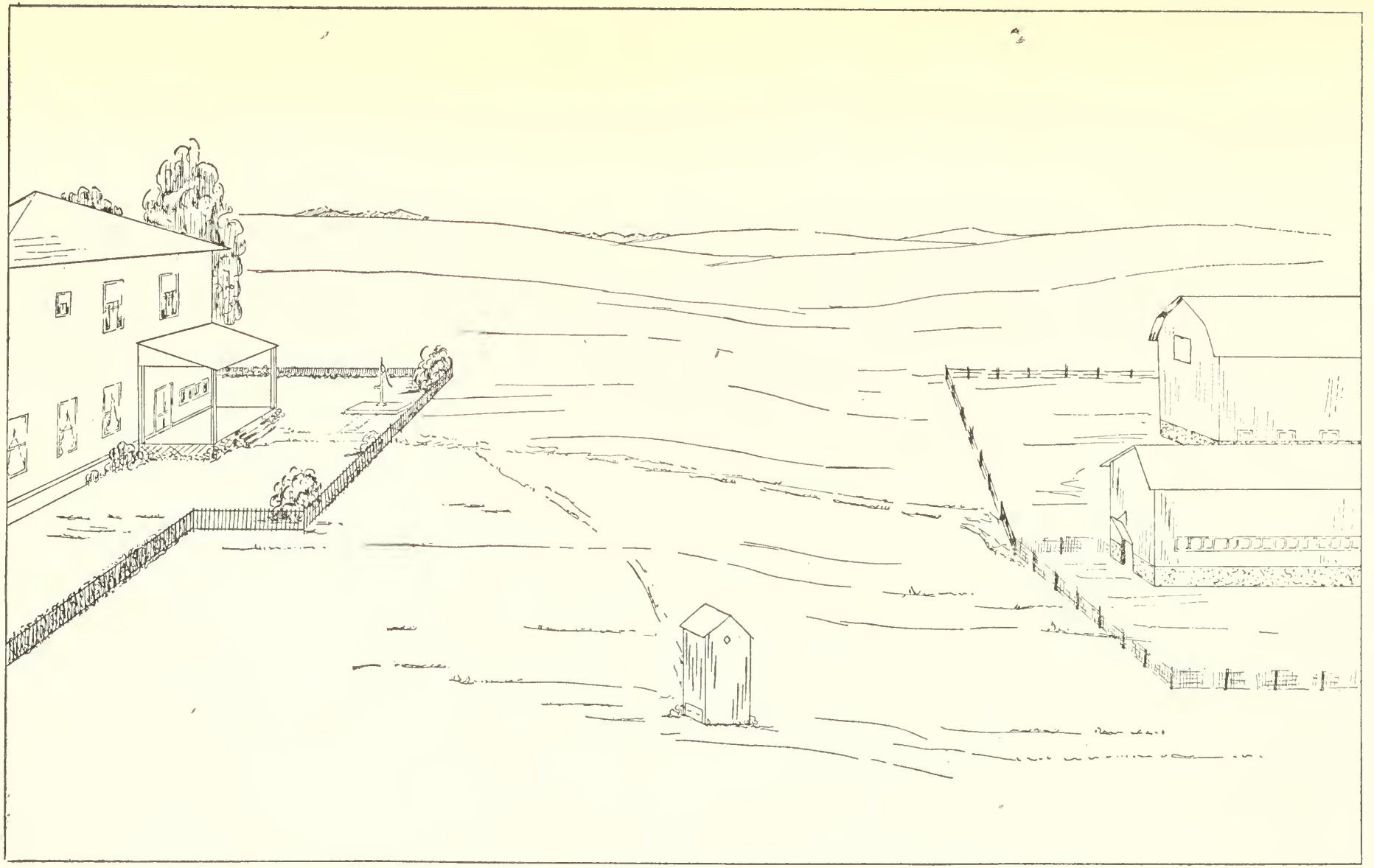

Fig. 8. Farm Habitation Showing a Pail Privy and a Properly Located and Constructed Well.

The privy should not be located on ground that slopes toward the well. Figure 5 shows an insanitary privy, improperly located with respect to a well. The well itself is poorly constructed.

Figure 6 illustrates a pail privy properly located and properly constructed.

Figures 7 and 8 each have titles which explain the points illustrated.

A pit-privy will soon deteriorate if not kept in repair. Repairs should be made as required in order to maintain the construction up to the specification of the original design.

The interior of the privy should be cleaned periodically. Disagreeable odors can in a measure be prevented by covering the excreta in the pit with a thin layer of fresh earth from time to time. The seat covers should be kept in good repair and always be closed when the privy is not in use in order to obtain protection from flies.

Lack of care in operation and in upkeep will soon lower the rating of a pit privy. If allowed to deteriorate, the pit-privy will in time be no better than a surface privy with a rating of 10 to 25 per cent.

**The Pail or Can System.**

A privy of the ordinary design provided with a pail or can to receive excreta represents a system that has, under efficient operation, a maximum rating of 75%. The pail or can system has a higher rating than the pit privy, on account of the water-tight construction of the receptacle which makes it possible to prevent the pollution of soil when proper methods of final disposal are used.

The present status of the pail or can privy is clearly stated by *Stiles. (In the original article Stiles remarks apply equally to both the can and vault systems. The authors have taken the liberty to change the quotation to apply to the can system only.)

> "The pail system (50 to 75 per cent) occupies a different position from that which it held five to ten years ago. The change in value is due to the fact that without efficient inspection, scavenging and disposal organizations, this system rapidly deteriorates to a surface system of 10 to 25 per cent value and, in considering this premise we are faced by the practical fact that labor is today scarcer, more expensive, and far less efficient than it was five to ten years back. The fundamental fact must be held constantly in mind that the success of this system depends upon efficient labor efficiently administered. If the choice lies between an inefficient can system on the one hand, and a fairly efficient pit system on the other, my preference is distinctly on the side of the pit. I cannot concur in the view that the can system is never feasible in rural districts, for this view is not in harmony with my experience; but this same experience leads me to maintain that health officers should insure proper inspection, proper scavenging and proper disposal as the first step in introducing the can. If these conditions are assured, I view the watertight can as a system which is conservative and proper to recommend as a practical system of sanitary privy; without these assurances I hold that it is not a system which should be recommended. It will, however, be necessary to permit it during the period that it is serviceable, and then condemn it as soon as it, like the pit, falls to a 10 per cent value. In summary; The can system is dependent more upon proper labor and administration than upon any other factor; and, until some better method is discovered to utilize safely the contents of the privy, this system must be viewed as somewhat expensive when compared with the pit privy".

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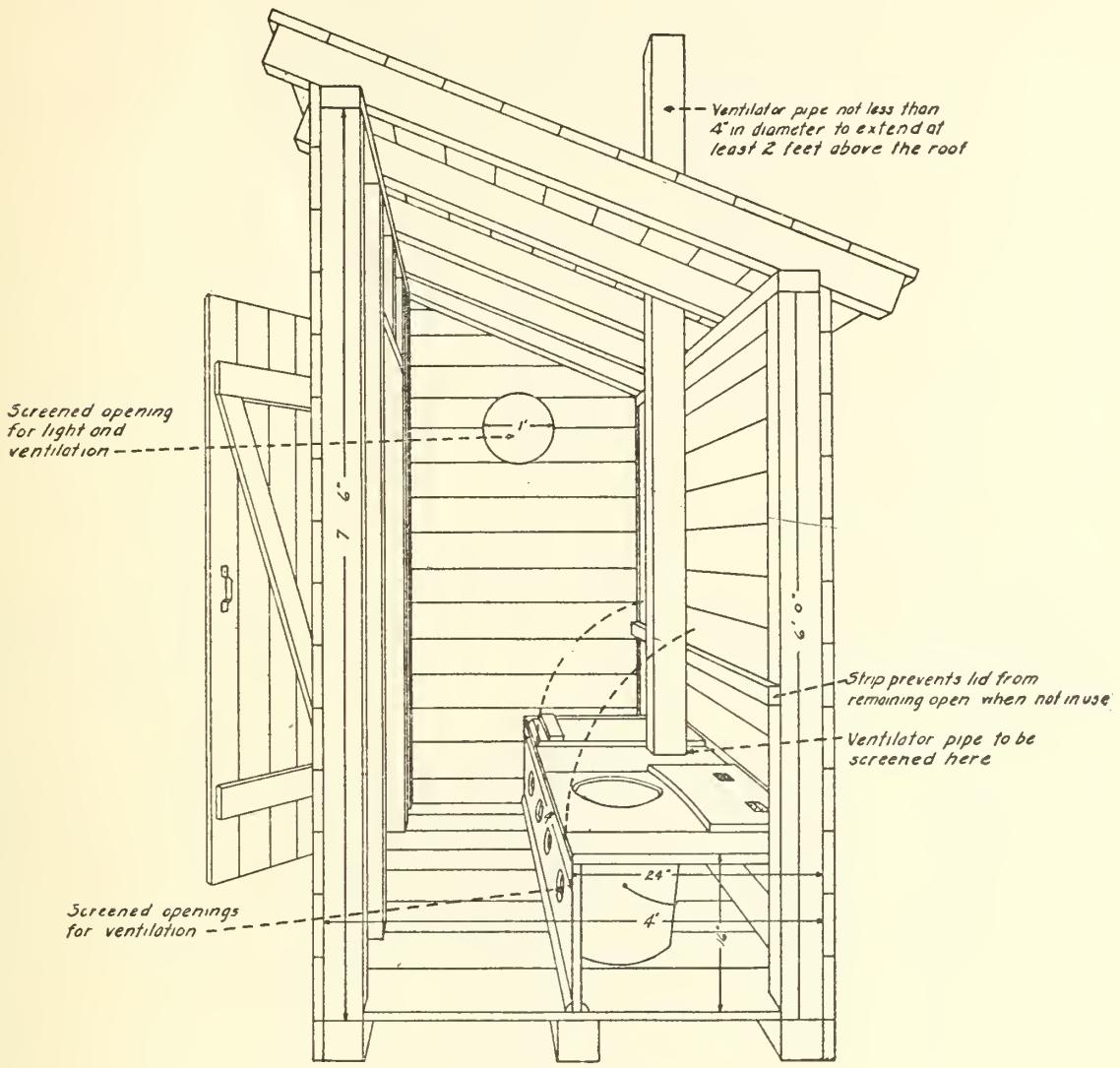
*Stiles American Journal of Public Health, Vol. X, No. 1, January, 1920.

Based on the premise of Stiles the pail or can system can be "recommended" both for isolated residences in the country and for unsewered villages and towns on the assurance that the system will receive "proper inspection, proper scavenging, and proper disposal".


Ventilator pipe not less than 4" in diameter to extend at least 2 feet above the roof
Screened opening for light and ventilation
1'
7' 6"
6' 0"
Strip prevents lid from remaining open when not in use
Ventilator pipe to be screened here
24"
4"
Screened openings for ventilation

PAIL PRIVY DESIGN
FOR USE IN
RURAL DISTRICTS
MONTANA STATE BOARD OF HEALTH

FIG. 9. DESIGN OF PAIL PRIVY.

Construction. The design of the privy for this system is shown in figure 9 and is similar to that of the pit-privy. In all particulars the construction of the two types is the same except for the modification necessary to collect the excreta in a pail or can instead of in a pit in the ground. Not only are the self-closing covers to the seat mounted on hinges, but also the seat itself is provided with hinges to facilitate the proper placing and removing of the receiving receptacles.

Figure 10 illustrates a design for a can recommended by the United States Public Health Service.

To convert an old pit privy to the receptacle type, it is only necessary to provide a new covered seat in the form of a box, to install a ventilating flue, and to board up the opening in the floor to serve as a support for the can.

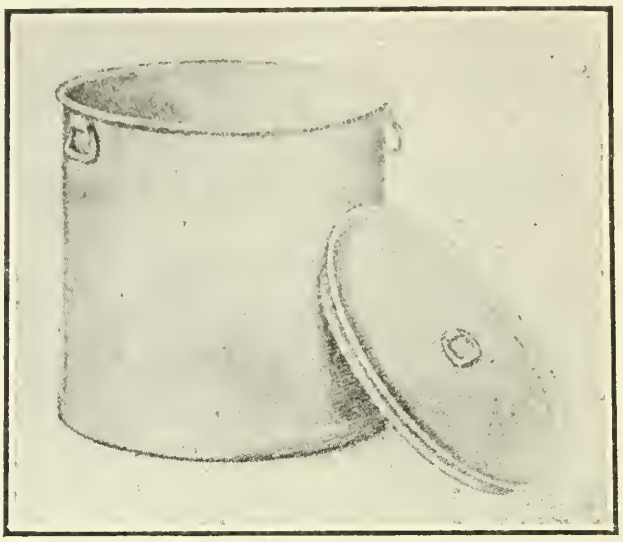


Fig. 10. Recepacle For Use in Pail Privy. Covers for Such Cans Are Necessary.

Figures 11 and 12 copied from designs of the United States Public Health Service illustrate the method of converting a pit privy into the pail or can type.

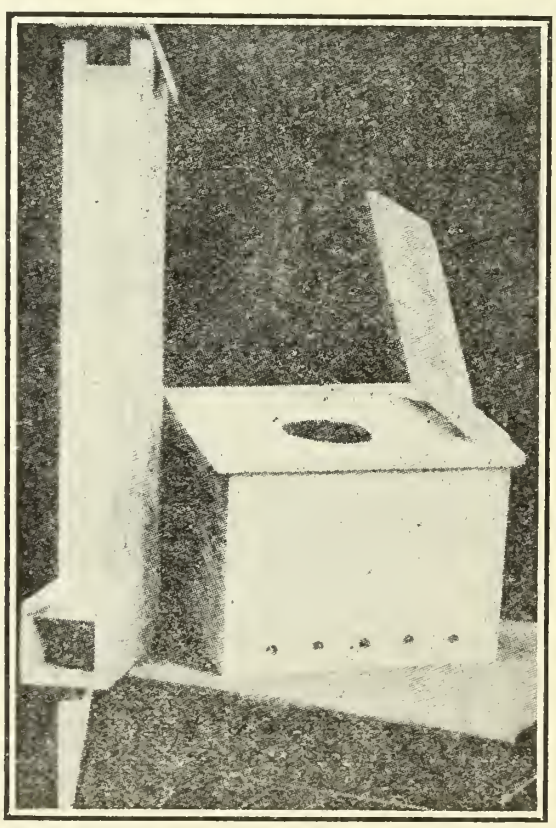


Fig. 11. New Box and Vent Flue Ready for Installation in Old Privy.

Upkeep and Operation. The privy should be kept in good repair so that it may have a continuous rating equal to that of the original design. Proper use of the privy involves precautions against soiling

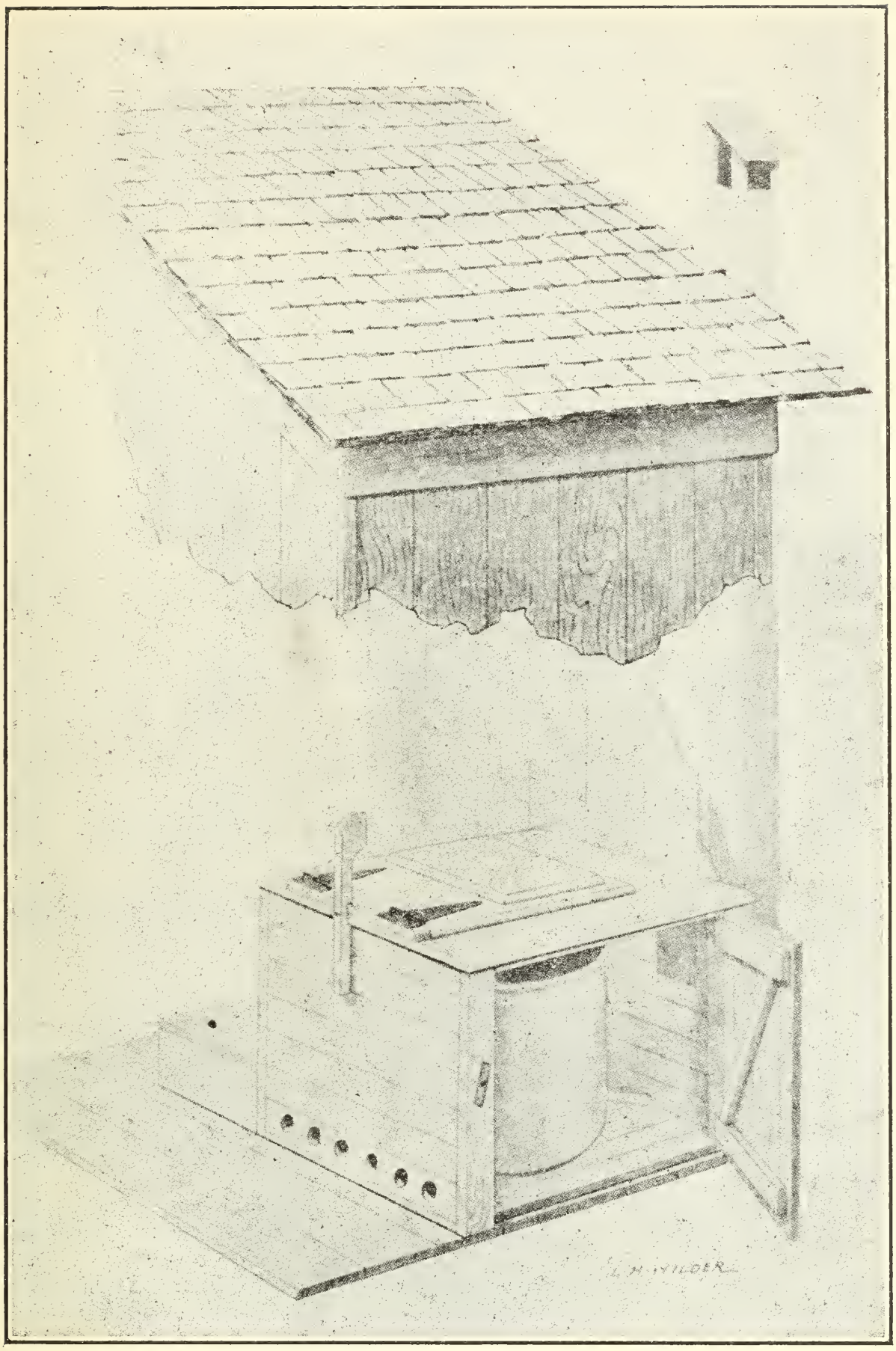


Fig. 12. One-can Fixed-Cover Box With Back Door for Removal of Can With End Ventilation. The Air Inlets Are At Left End of the Box and the Vent Flue Extends From the Right End of the Box Through and Up the Side of the Privy.

the floor, the seat or other parts of the privy with excreta. Periodic scrubbing of the interior wood work is desirable. The covers over the holes in the seat should be kept closed when the privy is not occupied. Otherwise flies will get into the excreta and thus the attempts to make the privy fly proof are wasted. If flies have gathered about the seat, they should be scared away before the cover to it is raised. Neglect to operate the privy in all these particulars against the access of flies to the excreta, lowers the rating of this system. The can should be removed and emptied before it becomes too full to be conveniently handled. Cans should be renewed when they become leaky.

If the ventilation provided in the design fails to control disagreeable odors, the contents of the can should be covered periodically with powdered dry earth. The drying effect of the earth also improves the condition of the contents of the can for subsequent disposal.

Scavenging and Disposal. *Stiles says that the first step in introducing the can system is to "insure scavenging and proper disposal. Without these assurances I hold that it is not a system which should be recommended".

With this understanding it follows: If the can system is used in a village, an efficient scavenging and disposal system should be provided. Since the can system will probably not meet with favor in Montana towns, the details of such a system will not be described. Complete information can be obtained from Reprint No. 532, United States Public Health Service." "A Disposal Station for a Can Privy System".

For a farm residence, disposal of privy contents by burial is a convenient method. A field which will not be cultivated for at least a year should be selected. The field should be a considerable distance from the residence and from the water supply. A trench eight to twelve inches deep should be dug. The contents of the can should then be spread along the trench to a depth of two or three inches and covered with earth. In this top layer of soil the excreta will undergo changes which will render it harmless in a few months.

### Cost.

The cost of the two privies described, including lumber, nails, hinges, and pail is approximately $20.00.

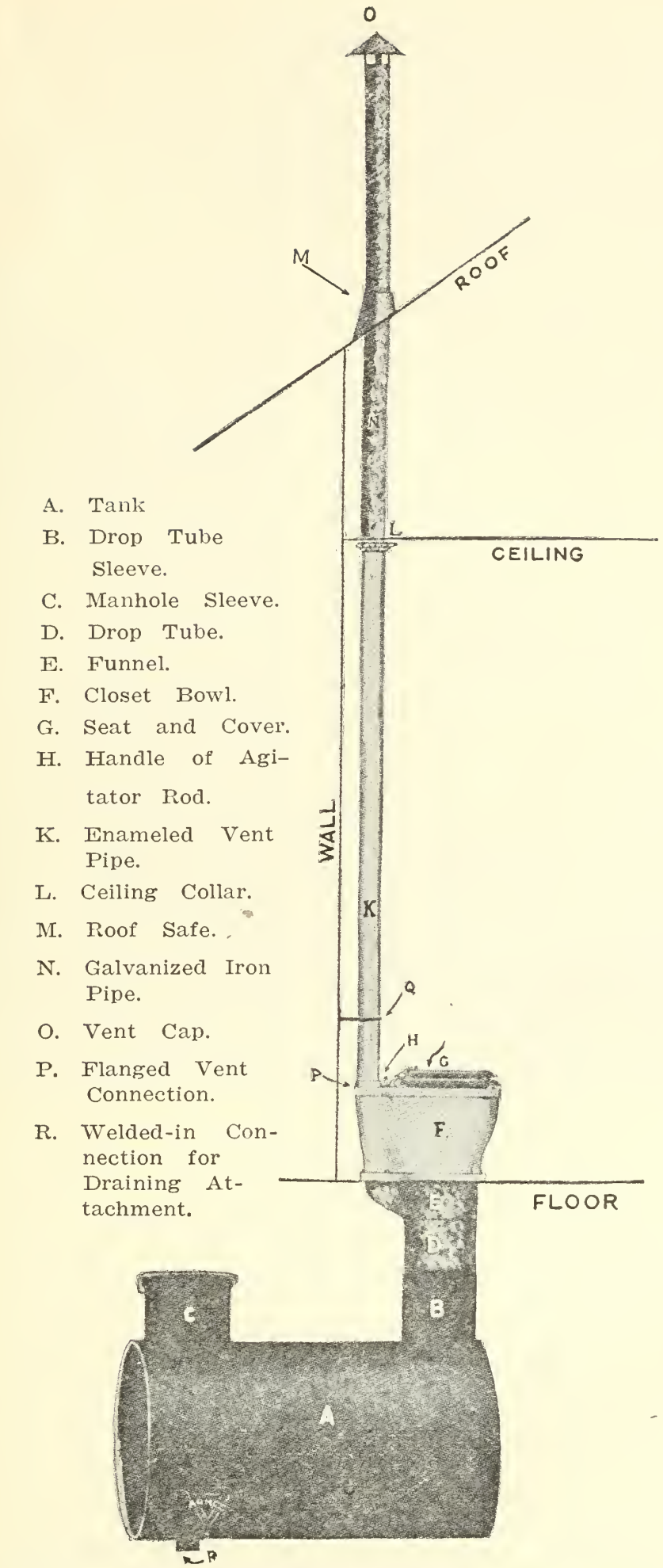
### The Chemical Closet.

The chemical closet is a device so constructed as to allow the depostion of excreta into a receptacle which contains a digesting, deodorizing, and disinfecting solution. There are two types. The commode type consists of a permanent seat of the usual kind, ventilated by means of a flue through the roof. A removable can containing the chemical disinfectant is placed under the seat. Removal of the receptacle and burial of the contents are necessary every two or three weeks.

The second type is provided with a seat of the same design as used in the water-carriage system. As in the first type ventilation is obtained by the use of a flue through the roof. The excreta is collected in a tank containing the disinfectant. The size of the tank is sufficient to warrant operation for several months without cleaning.

The tank can be emptied in one of three ways; by draining, pumping or dipping. Detailed discussions of these methods of emptying need not be given in this bulletin. The manufacturers of chemical closets explain fully all working details to their patrons. In general

*Stiles American Journal of Public Health, Vol. X, No. 1, January, 1920.




A. Tank
B. Drop Tube Sleeve.
C. Manhole Sleeve.
D. Drop Tube.
E. Funnel.
F. Closet Bowl.
G. Seat and Cover.
H. Handle of Agitator Rod.
K. Enameled Vent Pipe.
L. Ceiling Collar.
M. Roof Safe.
N. Galvanized Iron Pipe.
O. Vent Cap.
P. Flanged Vent Connection.
R. Welded-in Connection for Draining Attachment.

Fig. 13. Typical Connections of the Chemical Closet.

it may be stated that the method of draining into a tile system placed in soil or to a leaching pool is preferable to scavenging by pumping or dipping.

The chemical disinfectant used in the tank may be "an alkaline emulsion of a coal tar or oily disinfectant, the principal object being disinfection and deodorization, or a strongly caustic solution with or without other disinfectants with the additional object of rendering the tank contents semi-fluid".

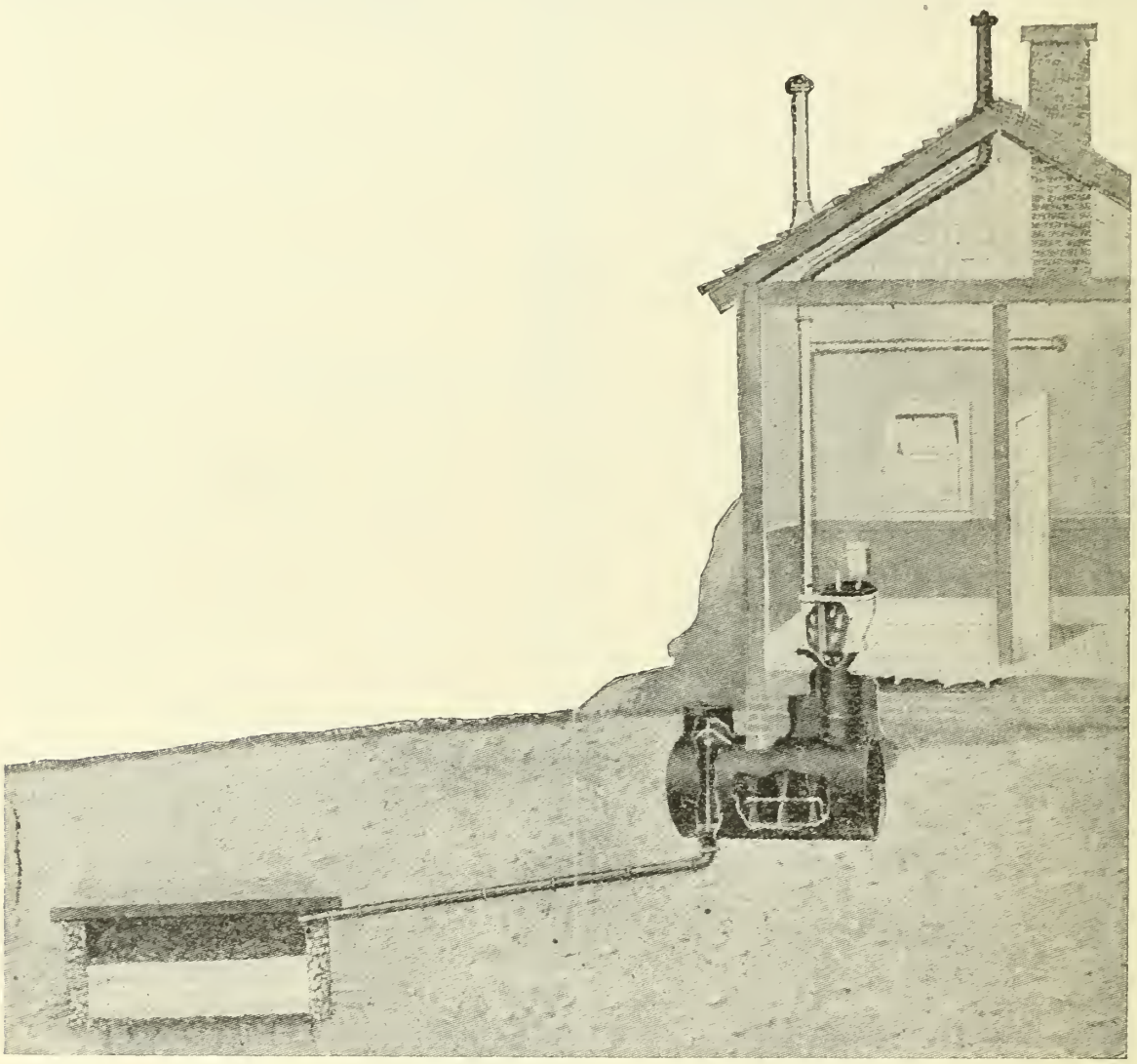


**Figure 14. Showing Installation of Chemical Closet With Tank Connected to Cesspool.**

The details of the tank type of chemical closet are sufficiently explained in figures 13, 14 and 15.

The maximum rating of a properly installed and properly operated chemical closet is 75 to 100%. This type of closet can be recommended for residences in towns and for farm homes when maintained and operated in a manner to warrant the maximum rating at all times.

The chemical closet has the advantage of not requiring running water, and of being a device that may be installed within the house. In this particular it approaches the convenience of the inside water closet.

Further advantages are simplicity of operation and safety and ease of finally disposing of the contents of the tank by drainage. The chemical closet is also capable of cleanly operation without disagree-

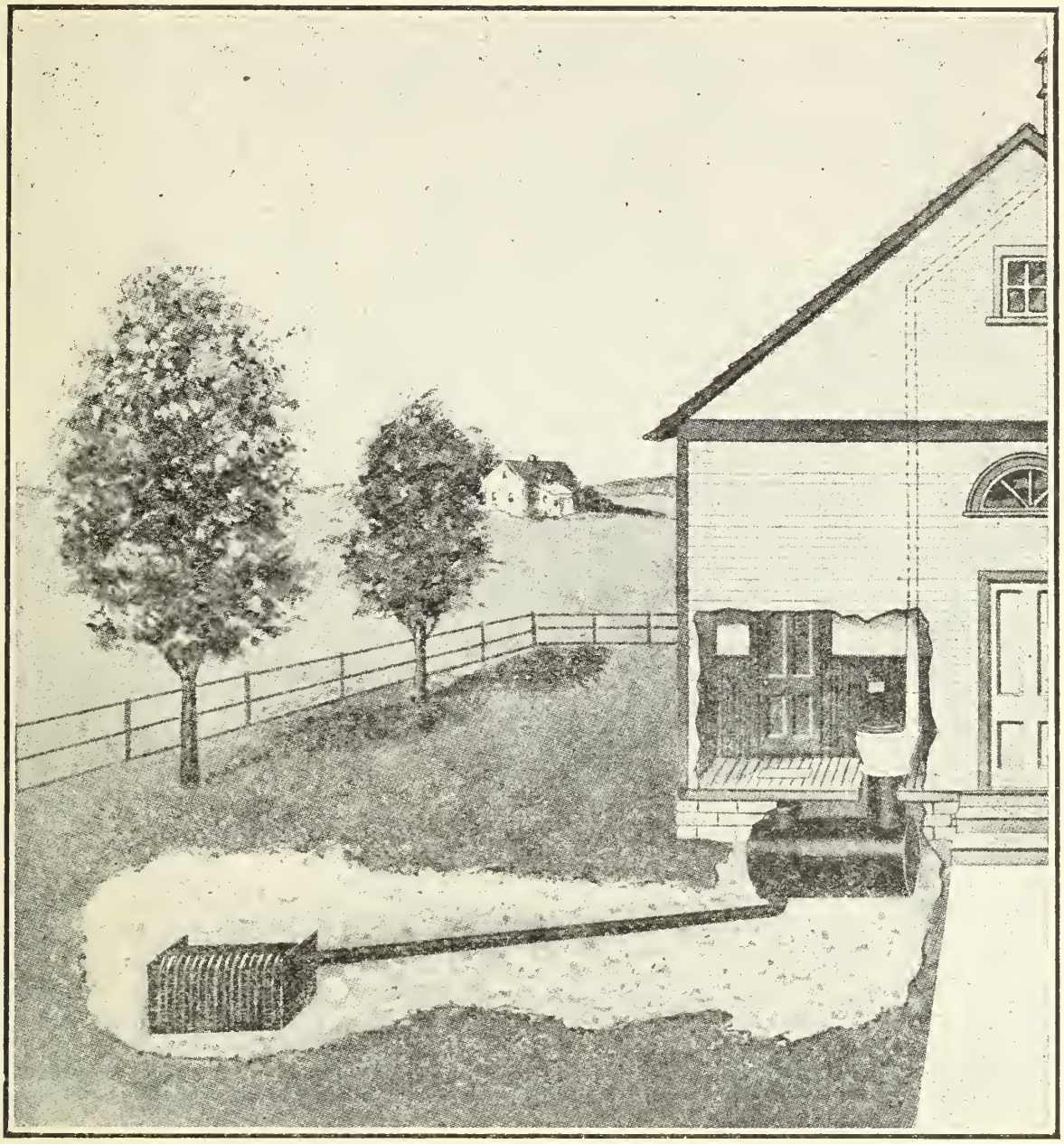


Fig. 15. Showing Installation of Chemical Closet With Tank Connected by Drain Pipe to Leaching Pool.

able odors. In these particulars this type of privy conforms to the requirements of a "sanitary" sewage disposal system and can be "recommended" as such.

Cost. The cost of the chemical closet is higher than the other types of privies previously described. Estimates of costs can be obtained from the manufacturers.

### Septic Tank and Sub-Surface Soil Distribution.

A system which includes a septic or settling tank and final disposal of the treated sewage automatically into the soil has a rating under proper conditions of practically 100 per cent and can be "recommended" for residences provided with running water. Such a system eliminates the necessity and consequently the danger of handling the sewage in any form by the hands or by implements since it is all carried by pipes from the house to the septic tank; thence to a soil distribution area for final disposal. The solids in the sewage are

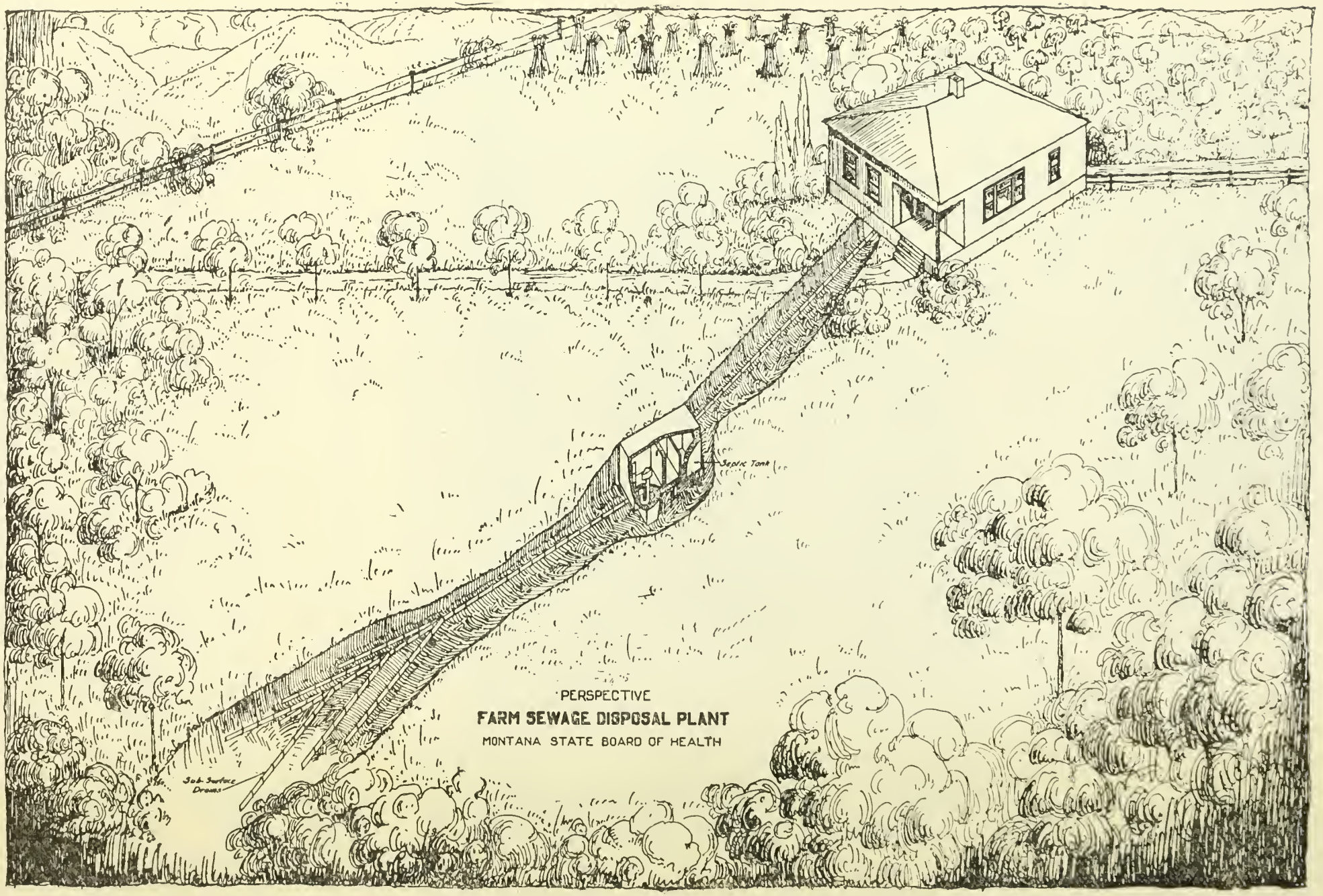



Fig. 16. Perspective Showing Location of the Septic Tank and Sub-Service Drains in Respect to the House.

liquefied in the septic tank, and the solution thus produced is distributed by a system of open tile to a soil area for final purification so that the dangers of contaminating the soil or the water supply and of scattering the excreta by flies and other means are all eliminated.

This system of sewage disposal is classed as "sanitary". It can be recommended for residences in the country, and for those in villages and towns which have no sewage system with universal house connections.

Running water is necessary for the operation of this system; it is therefore, limited in its application to residences with a water-pressure system.

Since a water closet is used this type has, from the standpoint of convenience, all the advantages of a city sewerage system. All drainage from the kitchen and bathroom can be treated in the septic tank and purified in the soil distribution area.

The Septic Tank. The solution or liquefaction of the solids is accomplished by bacteria normally present in sewage in the septic tank which is so constructed as to allow a settling and retention of the solids for from 8 to 24 hours—the length of time necessary for such liquefaction to be effected. The conditions best suited for this action are the absence of air and a quiet environment.

When the sewage enters this tank the solids, paper, fecal matter, etc. are immediately attacked by the bacteria and changed to soluble compounds; there remaining as solid matter only a very small percentage of the original which is called sludge. This slowly accumulates in the bottom. If the sewage is allowed to remain in the tank too long, obnoxious odors are produced. Consequently it is necessary to have the tank of the proper size and to have the flow of sewage through it properly regulated.

In practice the tank is constructed according to the plans and specifications shown, at some convenient place in the disposal system between the house and the point or area of final disposal (see figure 16).

During the period of retention allowed by the construction of the tank the solids are changed into soluble compounds, and the liquids thus obtained are conducted to some remote point for final disposal through pipes. Under ordinary conditions of construction and use, the cleaning of the tank is seldom necessary oftener than two or three years. At these times the cover of the tank is removed and the tank emptied of its liquid contents and also of the sludge which will have accumulated.

Location of Septic Tank. The septic tank should be located as near the house as is practicable. In some instances these structures are just back of the house or in the garden where they may be shielded from view by shrubbery. This is not necessary, however, as nothing need show above the ground except the cover, which should be even with the surface. The tank may be located in the front yard or any other convenient place easily accessible. It must, however, be lower than the source of all sewage to be treated. It is sometimes desirable to place the tank below the surface of the ground. In this case it should have no more than 12 or 16 inches of soil over it.

Construction of the Tank. Figure 17 shows a typical design of a tank and dosing chamber recommended for use by the average family of six persons. It consists of a preliminary compartment "A" into which the sewage flows. Some of the solids may settle here altho most of them pass over into the next compartment. The liquids displace those already present, causing them to flow over the baffle into the second compartment, "B". Further settling of solids is effected here. From this compartment the liquids which contain no solids, except perhaps some very finely divided material in suspension, pass

through the outlet pipe "C" into the dosing or siphon chamber "D". This fills slowly as the sewage enters the tank until the liquids reach a certain height, when the siphon "E" operates discharging the whole contents of this chamber through the outlet pipe "F" into the line leading to the point or area of final disposal.

The vitrified tile Tee "C" is an essential feature and is so placed as to form a trap which prevents the grease and scum from passing into the dosing chamber or into the disposal system.

The walls, bottom, top and baffle of the tank are best made of concrete composed of one part cement to two parts sand to four parts crushed rock. The walls and bottom should be eight inches thick. The top and baffle should be four inches thick. The top should be reinforced with any standard reinforcement or ¼ inch steel rods or strands of barbed wire spaced three inches apart and one inch from the bottom, running both lengthwise and across the slab. The other parts of the tank probably need no reinforcement as designed.

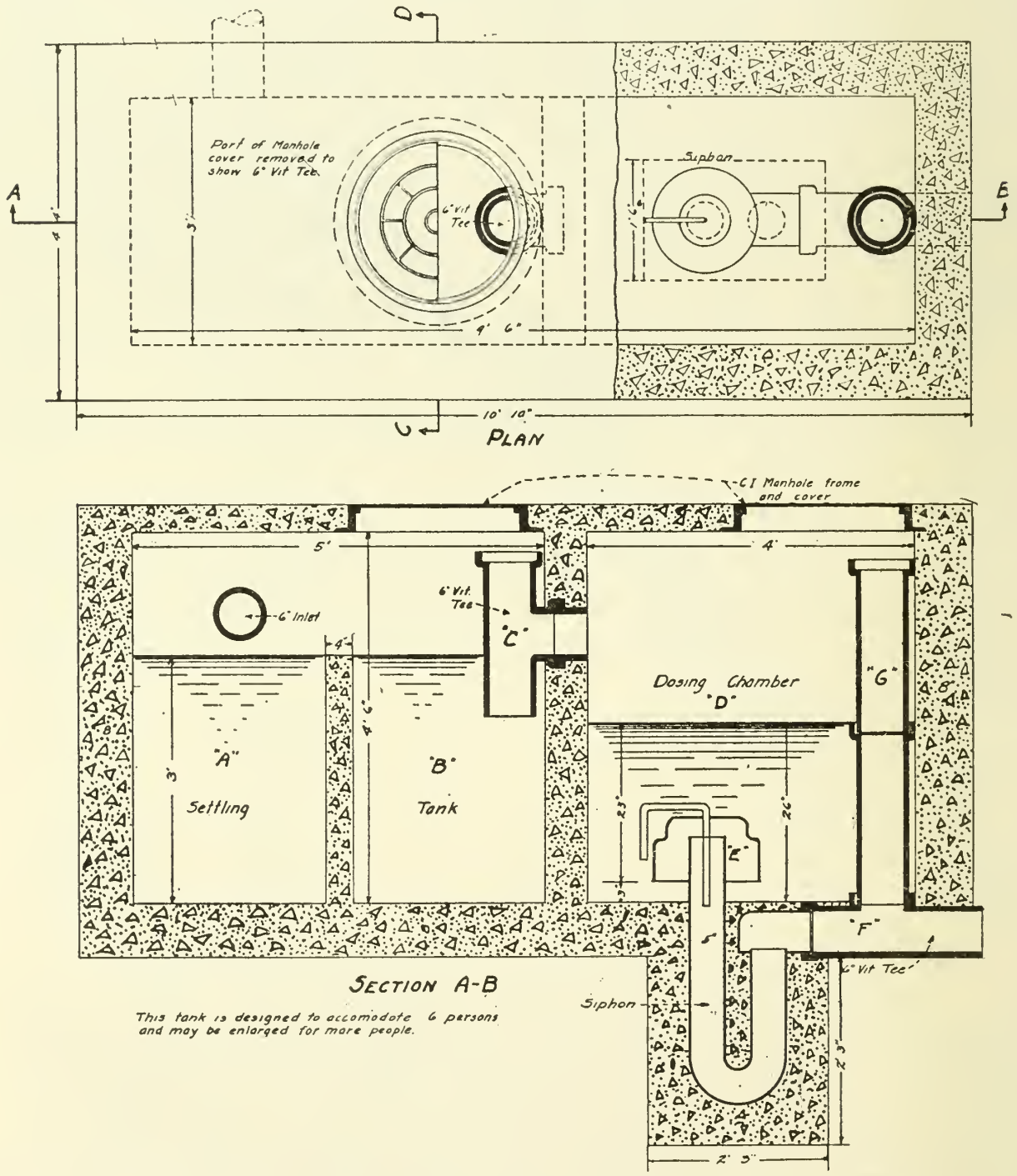



**Fig. 17. Showing Plan and Sections of a Septic Tank With Siphon or Dosing Chamber.**

Man-holes with tight-fitting covers of wood, iron or concrete should be provided as illustrated, to facilitate the cleaning of the tank. If it is desirable or necessary to build the tank with its top 12 or 18 inches below the ground, the man-holes should be built up accordingly in order to bring the covers even with the surface. The necessary piping (six inch vitrified tile) is placed in position before the concrete is poured, thus insuring tight joints.

The Siphon Chamber. The siphon or dosing chamber "D" collects the liquids coming from "A" and "B". These liquids are held here until they reach a certain height, when the siphon "E" operates, opening the outlet pipe "F," thus allowing a flooding or "dosing" of the disposal area. The pipe "G" is an essential feature. It serves as an overflow and is a safeguard against the "backing up" of sewage into the house in case the siphon should for any reason fail to operate. The top of this pipe should not be higher than two inches above the bottom of the inlet.

The siphon chamber has no part in the liquefaction of the solids, but its installation with the siphon is an advantage in that the disposal system discussed on the following pages will give better service where it is used.

The siphon shown is a "Miller Automatic five inch siphon" sold by dealers in plumbing supplies.

If local conditions are such as to make it possible to dispose of the sewage coming into the tank, into a stream or on the surface of the ground or into a light absorptive soil, the siphon chamber and siphon may be eliminated and the liquids led directly from the septic chamber to the point or area of final disposal. This reduces the initial cost of construction. Such a tank is illustrated in figure 18. The general features of construction are the same in both types.

Size of the Septic Tank. The size and dimensions shown in the illustrations are of a tank designed to care for the sewage from the bath, kitchen and toilets in the home of the average family of six people. It is not advisable to construct tanks of smaller size. For larger numbers of people the following dimensions should be used:

| Number of Persons | Length Ft. | Width Ft. | Depth Ft. |
|---|---|---|---|
| 8 to 20 persons | 6 | 3.5 | 4.5 |
| 40 persons | 9 | 4.5 | 5 |
| 60 persons | 9 | 5 | 5 |

Operation of the Tank. While this tank is designed to give the best service with the least effort on the part of the user, it will of necessity require watching and should be inspected often enough to insure its proper condition and operation. In case it is found that more solid material is coming over than is desirable, or that sludge is being carried out of the tank, it is an indication that the tank is not working properly or should be cleaned. The accumulation of sludge reduces the capacity of the tank, thus shortening the period for which the sewage is retained. This accumulation may, therefore, result in incomplete solution of the solids, or in the production of obnoxious odors.

When the tank is cleaned, an operation which may be necessary every year or two, the sludge may be buried, burned or dried. When dried it makes excellent fertilizer for the field.

### The Final Disposal of Sewage from the Septic Tank.

The liquids coming from the septic tank, while practically free from solids, are not in condition to allow of their disposal directly upon the ground or into a stream. The bacteria in the sewage have not decreased measurably during passage through the tank; neither

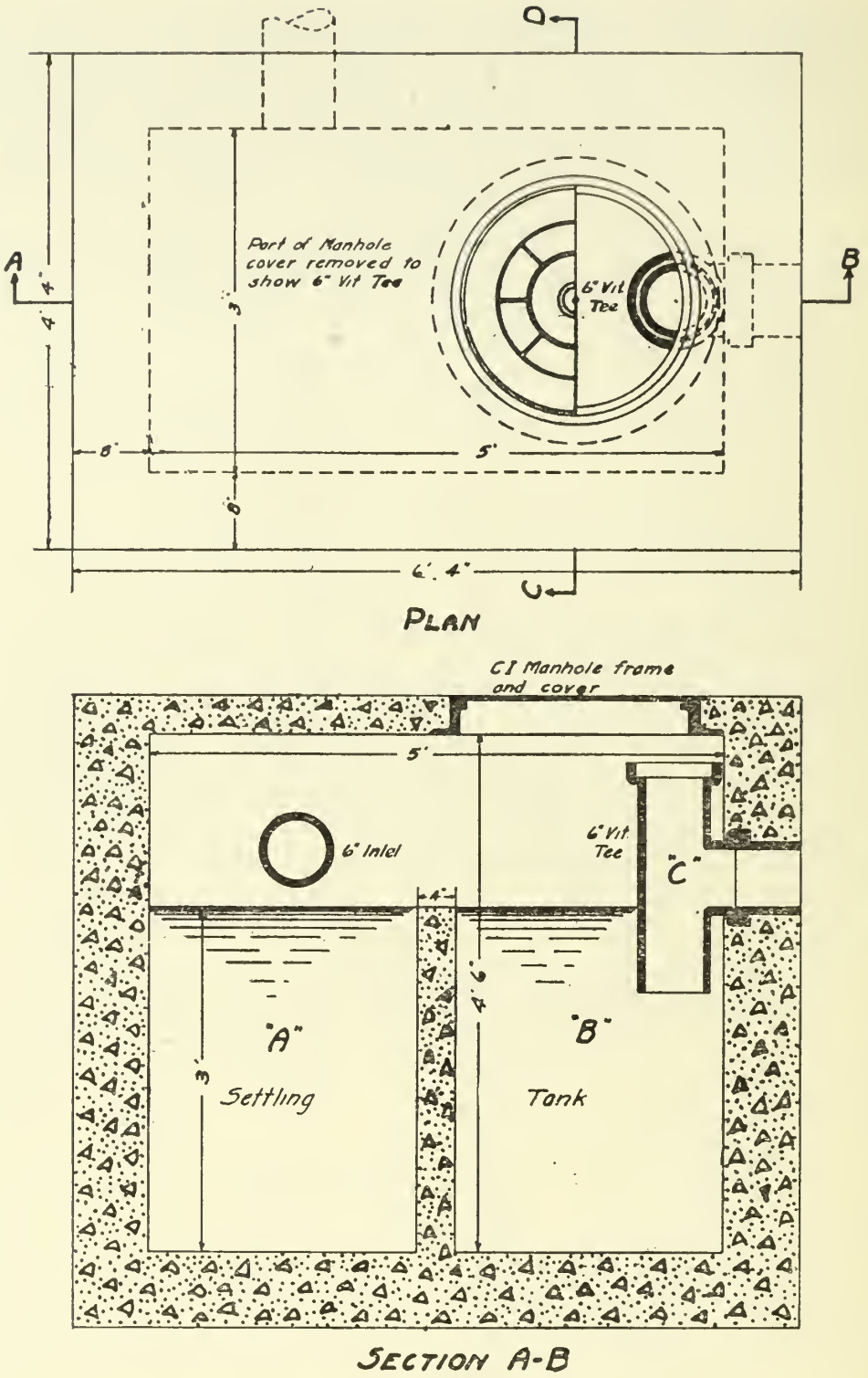



Fig. 18. Showing Plans and Sections of a Septic Tank Without Siphon or Dosing Chamber.

have the disease germs been eliminated. Only the physical condition of the excreta has been improved, and so changed as to make further treatment possible.

Again bacteria, this time those normally present in the upper layers of the soil, are employed. If the liquids flowing from the tank are allowed to filter through the upper layers of the soil, they are

freed from practically all bacteria and are oxidized by the air and bacteria of the soil, the chemical constituents being reduced to stable odorless compounds.

In practice then there is employed a system of tile so laid and extended as to distribute these liquids into the upper layers of the soil. This is called the "sub-surface irrigation" or "drain system" and is illustrated in figure 16.

Great care must be used in the construction of this final disposal system as the effectiveness of the treatment which is afforded depends entirely upon the proper disposal of the liquids and their contact with the purifying forces of the soil.

The Location of the Disposal Area. The location of the disposal area should be selected with care. It may be a lawn, field, orchard or pasture, but the requirements are that it shall be sufficiently extensive to contain the necessary length of tile pipe properly spaced, and so well drained that any water introduced into it will readily seep away. If the area is subject to flooding, trouble will be experienced in having water "backing up" into the system or even into the tank, or by the overflowing of the untreated tank effluent upon the surface of the ground.

The Soil of the Disposal Area. The character of the soil of the disposal area must be considered carefully also. That best adapted to the purpose is a coarse sandy or gravelly soil sufficiently porous to be readily drained. Very fine sand quickly chokes and clogs up the drain, thus shortening the period of usefulness of the system. Clay and other impervious solids make seepage so slow as to render the system almost useless. In limestone regions the fissures which are often present provide channels through which the sewage may pass so rapidly and directly to underground water courses as not only to prevent purification of the sewage but also to allow of the contamination of such water. Water-logged soils will not allow of proper drainage or purification.

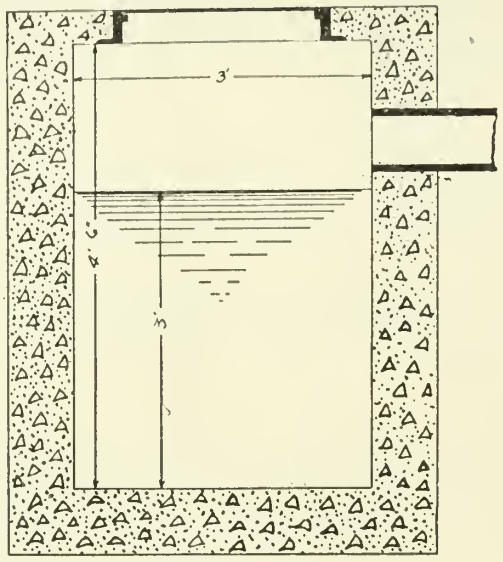
In tight clay soils wider and deeper trenches may be dug which should be filled with cinders or gravel, thus making a larger volumn of porous material for the purpose. A cross section of such a trench is illustrated in figure 20.

The Tile Distribution Lines. The effluent from the tank should be led through four or six-inch vitrified tile pipe, bell and spigot type, with tightly cemented joints laid with a fall of about 1 foot to every 100 feet, to the absorption or distribution tile. These latter drains are composed of 4 inch tile either of the bell and spigot type laid with open joints, or of common agriculture tile, allowing a space of ¼ inch between each length. The joints should be covered with tar paper, old pieces of linoleum, coarse broken pieces of tile or other material to prevent the spaces from filling with earth when covered. These should be laid carefully to grade having a fall of one-sixteenth inch to the foot in sandy or open soil and of not more than one-thirty-second inch to the foot in heavier soils.

The length of the tile distribution lines will depend upon the character of soil in which they are laid and upon the amount of sewage passing through them. In coarse sandy or gravelly soil 20 to 30 feet per person may be sufficient, whereas in tight soil 60 feet may be necessary.

The shape which the system takes will depend somewhat upon the shape of the area to be used. It is preferable, however, to divide the sewage, allowing it to pass into two or more lines of shorter length, rather than into only one of a greater length. Where more than one line is employed, they should be at least six feet apart, and better ten feet apart.

The distribution lines should rest upon coarse sand or gravel. If this is available at the proper depth, trenches wide enough to make work easy should be dug deep enough to allow a back fill of at least 12 inches from the top of the tile. A covering of 20 inches may be preferable in some cases, but it should not be greater than this. One authority says "The temperature of the sewage will prevent its freezing even in very severe winter weather, especially when the ground is

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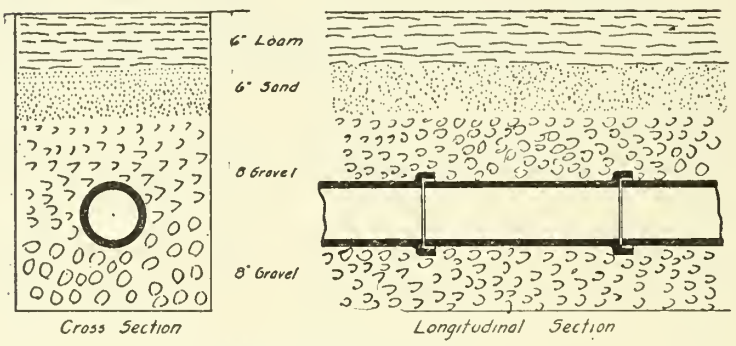


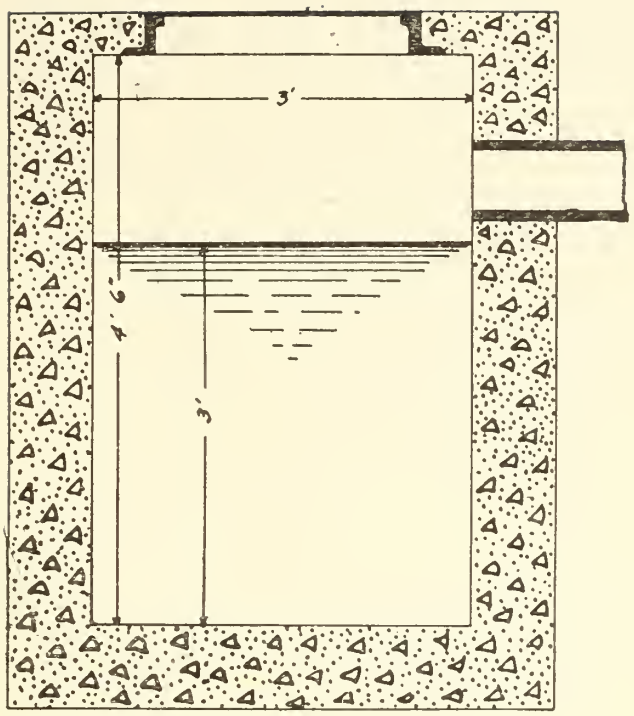

SUB-SURFACE DRAIN

SEWAGE DISPOSAL PLANT
FOR USE IN
RURAL DISTRICTS
MONTANA STATE BOARD OF HEALTH

Fig. 19. Sub-Surface Drain.

covered with snow." Experience in New Hampshire, Wisconsin, Maine and Montana indicates that where this tile system of distribution is used a maximum covering of 24 inches is sufficient at all times. Cross and longitudinal sections of a trench with pipe are shown in figure 19.

Where the soil is tight and relatively impervious a trench of the dimensions shown in figure 20 should be dug and filled with an absorptive medium for the sewage as illustrated.

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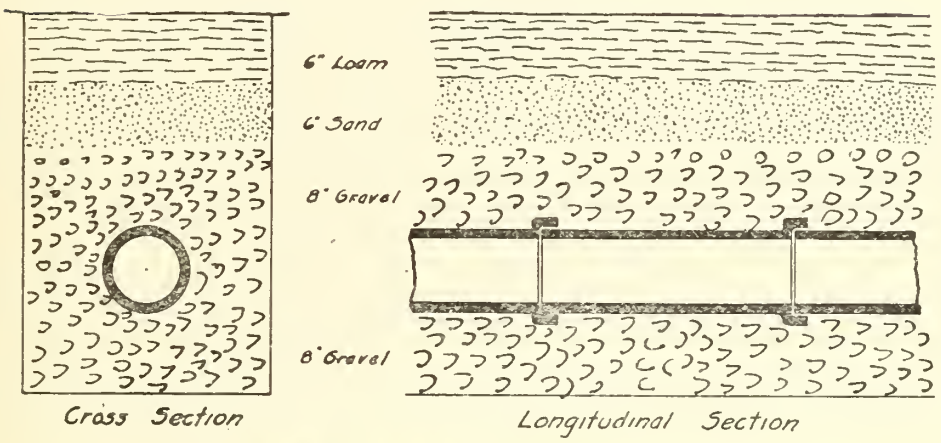


SUB-SURFACE DRAIN

SEWAGE DISPOSAL PLANT
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**Fig. 20. Cross and Longitudinal Section of Sub-Surface Drain in Tight Clay or Other Impervious Soils.**

The length of service of such a sub-drain system depends upon the amount of sewage going into it and the character of the filtering material. As in the case of the tank, the final disposal area should be watched for signs of improper operation. If the soil is properly absorptive and the grade of the tile proper, there should be no need of renewing the system for several years.

Before proceeding with the installation of such a system of sewage disposal as is described above, consultation with the local health department or an experienced engineer may prevent much unnecessary work or serious mistakes in important features of the work and this is advised.

Cost of the system. The cost of the system described above will vary with local conditions. A detailed tabulation therefore will not be given here.

Below are given, however, the amount of material used in the different devices and the amount of excavation necessary.

**Septic Tank—Without Dosing Chamber.**

| 6 People | 8 to 12 People | |
|---|---|---|
| 5.6 cu. yds. | 7.4 cu. yds. | Excavation |
| 3.2 cu. yds. | 4.0 cu. yds. | Concrete |
| 1 | 1 | Manhole Cover |
| 1 | 1 | 6-in.x6-in. Vit Tee |
| 2 ft | 2 ft. | 6-in. Vit. pipe |

**Septic Tank—With Dosing Chamber.**

| 6 People | 8 to 12 People | |
|---|---|---|
| 9.8 cu. yds. | 11.6 cu.yds. | Excavation |
| 5.5 cu. yds. | 6.2 cu.yds. | Concrete |
| 2 | 2 | Manhole Covers |
| 2 | 2 | 6in. Vit. Tile |
| 6 ft. | 6 ft. | |
| 1 | 1 | 5-in. Miller Siphon |

**Single Sub-Irrigation System.**

30 ft. 6-inch Vit. Pipe.

240 ft. 4-inch Vit. Pipe.

House sewer and sewer from tank to sub-irrigation system—350 ft. 6-inch Vit. Pipe.

**Other Types of Sewage Disposal Devices.**

The following type of privy have not been described in this bulletin. Those interested in these types can consult the references given.

The L. R. S. Privy.

The L. R. S. Privy is described in bulletin 68, United State Public Health Service. This apparatus consists of the following parts:

(1) A water-tight tank, barrel or other container, to receive and liquefy the excreta.

(2) A covered water-tight can, pot, barrel, or other vessel, to receive the effluent or outflow.

(3) A connecting pipe about 2½ inches in diameter, about 12 inches long, and provided with an open T at one end, both openings of the T being covered with wire screens.

(4) A tight box, preferably zinc lined, which fits tightly on the top of the liquefying barrel. It is provided with an opening on top for the seat which has an automatically closing lid.

(5) An anti-splashing device, consisting of a small board placed horizontally under the seat about an inch below the level of the transverse connecting pipe. It is held in place by a rod, which passes through a hole in the side of the seat and by which the board is raised and lowered. A layer of chips floated in the tank may be used instead of this anti-splashing device.

(6) A ventilating pipe, such as a stovepipe or wooden flue, connecting the space under the seat with the open air.

The liquefying tank is filled with water up to the point where it begins to trickle into the effluent tank. A pound or two of old manure should be added to the water to start fermentation. As an insect repellent a film of some form of petroleum may be poured on the surface of the liquid in each container."

In this type of privy the excreta is decomposed and liquefied in a water-tight tank or container and the liquid effluent from the tank is distributed to a soil distribution area or is collected in a separate container which is emptied from time to time.

This type of privy is classed as "sanitary" and has a high rating for some climates. The writers have not described the L. R. S. privy in this bulletin because there is some question regarding its adaptability to winter conditions in Montana.

### Vault Privy.

This type of privy is described in detail in bulletin 68 of the United States Public Health Service. In this type the receptacle is a stationary water-tight vault made of concrete. The vault is constructed in such a manner that the excreta is removed through an opening at the rear of the privy. This privy has not been described in this bulletin. For conditions under which a receptacle privy would likely be used in Montana, the writers have felt that the can or pail privy was more suited to local conditions.

## CESSPOOLS.

The disposal of sewage in an ordinary cesspool cannot be recommended for Montana conditions and should not be tolerated. In this method of disposal the sewage is digested in an exacavation in the ground. The effluent gradually seeps into the ground and surrounding formation. Montana soil conditions are such that this method in most localities would be a serious menace to underground water supplies. For this and other reasons the writers feel that the cesspool should not be permitted or tolerated only under the most favorable conditions.

## SUMMARY.

This bulletin contains designs, descriptions and sanitary ratings of several sewage disposal devices suitable for residences in unsewered districts. For each device directions regarding upkeep and operation are given. Summarizing the main points regarding each disposal system, the following statements express the more important conclusions.

The pit privy, even when constructed under improved designs, cannot be classed as "sanitary." The maximum rating of this type is only 50% even when properly constructed and operated. With this rating the pit type of privy can be "permitted" on the farm under present sanitary standards, but it is not recommended as a "sanitary" system. In villages and towns the pit privy should be classed as a type to be "tolerated" temporarily until a water carriage sewage system can be constructed for the entire town or until each residence can be provided with a separate sanitary system.

A properly constructed can or pail type has a higher rating than the pit privy; the maximum varying from 50 to 75%. This system can be classed as "sanitary" when properly constructed and operated. Therefore, it can be recommended both for farm residences and for unsewered villages and towns on the assurance that the system will receive proper inspection, proper scavenging and proper disposal. Without this assurance the system cannot be recommended.

The chemical closet and the septic tank with soil distribution of the sewage effluent are classed as sanitary and have a rating between 75 and 100%. In order to merit this rating both systems must be properly constructed and properly operated. Both of these systems can be recommended for residences in unsewered districts both in the country and in villages and towns.

Other sewage disposal systems are mentioned in the bulletin. The L. R. S. privy is classed as "sanitary" and has a high rating. This type of privy has not been described in this bulletin because there is some question regarding its adaptability to winter conditions in Montana.

A privy with a concrete vault meets with favor in some localities. In this bulletin the pail or can privy is recommended in its place for conditions under which a receptacle privy would likely be used in Montana.

The ordinary cesspool cannot be recommended for Montana conditions and should not be "tolerated." In most localities in Montana, the cesspool would be a serious menace to the purity of the underground water supply.


## ACKNOWLEDGMENTS.

In writing this bulletin the authors have freely consulted publications of the United States Public Health Service and bulletins of various state departments of public health. In some instances illustrations have been copied from these publications. This is particularly true of bulletins published by the Public Health Service and the Minnesota State Board of Health. Proper credit is given in the text for the assistance received.

The authors are indebted to the Kaustine Company, Buffalo, New York, for the privilege of using cuts of chemical closets.

Acknowledgment is due Widener and Truitt, Consulting Engineers, Bozeman, for several illustrations and for advice on the engineering design of the various sewage devices described. Appreciation of their assistance is herewith expressed.